# THE EFFECT OF ABRASIVE WATER JET TURNING PARAMETER OF INCONEL 718 ALLOY DIMENSIONAL ACCURACY AND SURFACE ROUGHNESS

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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Tajuk: **THE EFFECT OF ABRASIVE WATER JET TURNING PARAMETER OF INCONEL 718 ALLOY DIMENSIONAL ACCURACY AND SURFACE ROUGHNESS.**

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# DECLARATION

I hereby, declared this report entitled “The Effect of Abrasive Water Jet Turning Parameter of Inconel 718 Alloy Dimensional Accuracy and Surface Roughness” is the result of my own research except as cited in references.

Signature : ……………………………………….
Author’s Name : AINAA SHAMIRA BINTI JEFRI
Date : 08 February 2021

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# APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

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**(PM DR. MOHD SHAHIR BIN KASIM)**

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# ABSTRAK

Mesin konvensional mempunyai banyak masalah, terutamanya dari segi jangka hayat alat, produktiviti, dan kemasan permukaan. Abrasive Water Jet Turning (AWJT) adalah alternatif untuk pemesinan konvensional. AWJT adalah sejenis proses pemesinan yang tidak konvensional yang menggunakan jet air bertekanan tinggi yang dicampurkan bersama-sama dengan zarah kasar. Ia sangat sesuai untuk bahan yang paling sukar dan bahan kerja silinder. Inconel 718 Alloy adalah bahan yang akan digunakan untuk projek ini. Aloi Inconel 718 dikenali sebagai bahan paling sukar dan sangat sukar untuk mesin menggunakan kaedah konvensional. Inconel 718 Alloy mempunyai kombinasi ketahanan kakisan, ketahanan pengoksidaan dan ketahanan merayap yang sangat baik. Bahan jenis ini biasanya terdapat di industri kapal terbang.

Penyediaan bahan, menjalankan mesin, pengumpulan data, dan analisis data adalah empat tahap dalam penyelesaian projek ini. 8 sampel dengan diameter 16 mm dan panjang 50 mm akan dimesin menggunakan mesin AWJT. Reka bentuk full factorial terlibat dalam projek ini untuk memastikan bahawa eksperimen dijalankan secara sistematik dan cekap. Semua data dikumpulkan dengan menggunakan mesin kekasaran permukaan dan mesin penguji kebulatan. Data dianalisis dengan mengunakan ANOVA dan untuk mengenal pasti kesan signifikan parameter dioptimumkan atau tidak.

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# ABSTRACT

Conventional machines have a lot of problems, particularly in terms of tool life, productivity, and surface finishing. Abrasive Water Jet Turn (AWJT) is an alternative to conventional machining. AWJT is a type of unconventional machining process that uses a high-pressure water jet that is mixed together with abrasive particles. It is very suitable for the hardest material and cylindrical workpieces. Inconel 718 Alloy is the material that will be used for this project. Inconel 718 alloy is known as the hardest material and is very difficult to machine using conventional methods. Inconel 718 Alloy has an excellent combination of corrosion resistance, oxidation resistance and creep resistance. This type of material is usually found in the aircraft industry.

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The preparation, experimentation, data collection, and data analysis are four stages in the completion of this project. 8 samples with a diameter of 16 mm and a length of 50 mm will be machined using the AWJT machine. A full factorial design is involved in this project to ensure that the experiment is carried out in a systematic and efficient manner. All the data is collected by using a surface roughness machine and a roundness tester machine. The data is analyzed by using ANOVA and to identify the significant effect of the parameter is optimized or not.

# DEDICATION

To my beloved father, Jefri bin Muhamad,

my appreciated mother, Norliza binti Yaacob,

my adored sister and brother, Efi, Emy and Ernie,

for giving me moral support, money, cooperation, encouragement, and also understandings

Thank You So Much & Love You All Forever

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for guiding me through the whole research project

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My friends and technician especially Mr. Syafiq,

The Water Jet lab technician who is involved in this study and project,

May Allah ease our journey and bless all of us. InshaAllah.

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Furthermore, I would also like to acknowledge with much appreciation the crucial role of the staff of the Faculty of Manufacturing Engineering (FKP) and Faculty of Mechanical and Manufacturing Engineering Technology (FTKMP), who permitted to use all required equipment and the necessary materials to complete the study. Last but not least, I want to thank all lecturers, staff, and my friends who had to help me going through this study and for all knowledge and experiences that I have gained which lead to the completion of my study.


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# LIST OF ABBREVIATIONS, SYMBOLS, AND NOMENCLATURES

| | | |
|---|---|---|
| AWJ | - | Abrasive Water Jet |
| AWJT | - | Abrasive Water Jet Turning |
| AWJM | - | Abrasive Water Jet Milling |
| NNS | - | Net Near Shape |
| 3D | - | Three dimension |
| MRR | - | Material Removal Rate |
| SEM | - | Scanning Electron Microscope |
| DoE | - | Design of Experiment |
| DOC | - | Depth Of Cut |
| CNC | - | Computer Numerical Control |
| CCD | - | Central Composite Design |
| CAD | - | Computer-Aided Design |
| CAM | - | Computer-Aided Manufacturing |
| ANOVA | - | Analysis of Variance |
| DF | - | Degree of Freedom |
| SS | - | Sum of Square |
| MS | - | Mean Square |
| LLL | - | Life Long Learning |
| DTI | - | Dial Tester Indicator |

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| | | |
|---|---|---|
| R | - | Roundness |
| f | - | Feed rate |
| N | - | Rotational Speed |
| Ra | - | Surface Roughness |
| $Dim_e$ | - | Diameter Error |
| A | - | Area |
| p | - | Perimeter |
| e | - | Eccentricity |
| b | - | Minor axis |
| a | - | Major axis |
| % | - | Percent |
| mm | - | Millimetre |
| µm | - | Micrometer |
| °C | - | Degree Celsius |
| MPa | - | Mega Pascal |
| mm/min | - | Millimetre per minute |
| m/min | - | Meter per minute |
| cm/min | - | Centimeter per minute |
| rpm | - | Revolution per minute |
| Hz | - | Hertz |

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| | | |
|---|---|---|
| g/s | - | Gram per second |
| mm/s | - | Milimeter per second |

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background of Study

The majority of the technological advances need a new era of advanced material applications in various engineering fields. However, most of these materials have specific characteristics that cannot be machined using traditional manufacturing methods. Different machining technologies have been developed in the last few decades for processing several shapes of components.

Unfortunately, each of these technologies has its limitations for giving excellent efficiency and accuracy. Meanwhile, Abrasive Water Jet (AWJ) machining has been proven to cut various material shapes without any excessive force or thermal damage. AWJ machining often finds work cutting hardened steels, Ti- alloys, aerospace alloys, and other materials that are difficult to machine using conventional methods.

Water jet technology is one of the fastest-growing major machine tool processes globally because of its flexibility and simple operation. The garnet abrasive is used in the water jet stream. Without the abrasive, it can cut soft material only. Abrasive water jet can cut any thickness from smallest to most significant in high or low volume. There are two types of

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AWJ machining: Abrasive Water Jet Turning (AWJT) and Abrasive Water Jet Milling (AWJM).

AWJT is usually used to reduce the diameter of a cylindrical workpiece. The main difference between AWJT and AWJM is that the part that will be machined will rotate for turning operation, while for milling operation, the tools will rotate. AWJT is a technology that uses a high-pressure water jet that combines with abrasive particles. This technology is very suitable for the most challenging material that is very difficult to remove the unwanted shape. AWJT technology is also ideal for turning near net shape (NNS) and profiling grinding wheels.

In this research, AWJT will be discussed due to their ability to machine more rigid material such as Inconel 718 alloy with a cylindrical shape. Inconel 718 alloy is usually used on aircraft turbine engines for the aerospace industry. The modern aircraft turbine engines offer more reliability than the existing aircraft turbine engines. The most important factors to react to the higher reliability for the turbine engines are that the engineering teams must ensure these engines can be maintained, used for several years, and have excellent efficiency.

Inconel 718 alloy, also known as super alloys where the material can be machined at a temperature exceeding 1300˚F. It is also one of the materials that are very difficult to machine. In the aircraft industry, the Inconel 718 alloy is the perfect material to withstand various higher temperature corrosions and stress conditions that can occur in the turbine engine. Inconel 718 alloy also has an excellent combination of high-temperature corrosion resistance, oxidation resistance, and creep resistance. During machining Inconel 718 alloys, there will be several challenges such as generates more heat at the tooltip, causing excessive tool wear, and others. The other application for Inconel 718 alloy is 3D printing technology, die casting, oil and gas industries, saltwater applications, and others.

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## 1.2 Problem Statement

Inconel 718 Alloy's material has become one of the commonly used in the aerospace industry, chemical industry, and others. Nowadays, this material has been frequently used in gas turbine engines because Inconel 718 alloy has excellent tensile strength, ductility, fracture toughness, creep resistance, and fatigue resistance. Vrushali and Dalu (2017) states that it is difficult to machine the Inconel 718 Alloy material by using a conventional method due to Inconel 718 alloy produces poor results during the machining process Inconel 718 alloy tends to react with cutting tool material at the highest temperature.

Conventional machining has been used widely in the field of metal processing. When it comes to machining the material, the most important of traditional machining is physical contact between the tool and the workpiece. Thus, it can lead to tool wear since physical contact is required to perform the work. Friction is one factor of tool wear where the amount of heat is generated during the machining process. Anthony *et al.*(2017) conducted a study about the tool wear during machining Inconel 718 alloy concluded that in machining the Inconel 718 alloy material, the tool wear is influenced by thermal softening, adhesion, diffusion, notching, and thermal cracking. Thus, it can conclude that several factors were influenced during machining Inconel 718 alloy using conventional machining.

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During the metal cutting using the conventional method, the metal will absorb the heat that transmits away from the cutting, and it will cause the heat-affected zone on the workpiece. It occurs when the material of the workpiece, which is Inconel 718 alloy, is harder than the tool's material. Heat affected zone is also known as a non-melted area of metal and directly affects the surface roughness of the workpiece.

Abrasive Water Jet Turning (AWJT) is the best solution to overcome these problems. Unfortunately, the study of surface roughness of the Inconel 718 alloy and productivity is questionable. The research about the parameter of AWJT is very important to overcome all the problem occurs in conventional lathe machine and to increase the knowledge of the appropriate parameter to produce the highest quality of the product by using AWJT.